

Effect of Organic Alcohol Additives on the Shape for Electrodeposited Ni Microprobes

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Recently, in the field of electronic industry, reliability of semiconductor chips is one of the key factors for higher performance electronic instruments. Therefore, it is very important process to test the function of semiconductor chips. In these days, attachment for testing the so-called “probe card” constructed with microprobes attached to LSI pads and test circuit is used to check the function. Generally, probes are fabricated by full-additive method using chemical vapor deposition (CVD) of tungsten (W). But this method has disadvantage to fabricate probes in large number on complicated pattern. Especially, they have to be fabricated with cheap production cost. In this situation, we have proposed new method of fabricating nickel (Ni) microprobes with high aspect ratio by electrodeposition using thinner patterned photoresist¹⁾. By compared with the conventional method, this new method has some advantages on cost and mass productivity because of using Ni electrodeposition and thinner photoresist developed by ultraviolet ray (UV) radiation, while there is problem that nickel deposits tend to grow in horizontal direction than in vertical direction with making the shape of probe flat. In our previous study, we reported that the form of nickel probe changes from a flat to an oval shape with a high aspect ratio by addition of propargyl alcohol into the plating bath²⁾. In this study, the relation between the probe shape and the molecule structure of organic additive compared with propargyl alcohol was investigated. Especially, the effects of unsaturated bonding of carbon atoms, OH group and number of carbon in the structure of additive molecule to the probe shape were investigated.

Probes were fabricated by electrodeposition carried out at constant current of 0.636 mA for 60 min. from nickel sulfamate bath containing various alcohols as an additive. Concentrations of additive were optimized by pre-experiment. Vacuum-evaporated Cu/Cr on Si wafer was used as substrate, on which 32 $\mu\text{m}\phi$ holes were formed using about 4 μm thick positive photoresist film (PMER P-MH600PM T-1, Tokyo Ohka Kogyo Co. Ltd.) made by a UV developing method. The action surface area for Ni deposition is about $8.04 \times 10^{-4} \text{ cm}^2$. The probe profiles and surface morphology were observed by scanning electron microscope (SEM), optical microscope and surface profilometer.

Firstly, the effects of the unsaturated bonding in the additive on probe shapes were investigated using $\text{HC}\equiv\text{C}_2\text{H}_2\text{OH}$ (propargyl alcohol), $\text{H}_2\text{C}=\text{C}_2\text{H}_3\text{OH}$ (allyl alcohol) and $\text{H}_3\text{C}-\text{C}_2\text{H}_4\text{OH}$ (1-propanol). These alcohols have same carbon arrangement with different unsaturated bonding state between C2 and C3. From Fig. 1a), Ni probe made from $\text{H}_3\text{C}-\text{C}_2\text{H}_4\text{OH}$ bath is similar in shape to that made from additive-free bath. However, the probes obtained from $\text{HC}\equiv\text{C}_2\text{H}_2\text{OH}$ and $\text{H}_2\text{C}=\text{C}_2\text{H}_3\text{OH}$ bath were quite

different shapes from that made from other two baths. With changing bonding state of additive from single bond to triple bond, deposited mass of the probe increased and the shape changed from a flat to an oval. Especially, $\text{HC}\equiv\text{C}_2\text{H}_2\text{OH}$ was most effective additive to increase aspect ratio. Moreover, effect of the unsaturated bonding in the additives which have four carbon atoms and two OH groups but have different unsaturated bonding was investigated, the oval shape probe was obtained only from 2-butyn-1,4-diol (with one triple bonding as same as $\text{HC}\equiv\text{C}_2\text{H}_2\text{OH}$) bath. From these results, it was confirmed that triple bond in the molecule structure of an organic alcohol was very important factor for the high aspect ratio deposits.

Secondly, effects of the OH group in the additive molecule on the probe shape were investigated. Figure 1b) shows the probe profile fabricated by using $\text{HC}\equiv\text{C}_4\text{H}_6\text{OH}$ (4-Pentyn-1-ol) which had one OH group and $\text{HC}\equiv\text{C}_4\text{H}_7$ (1-Pentyne) without OH group. Oval shaped probes could be obtained by using $\text{HC}\equiv\text{C}_4\text{H}_6\text{OH}$, while the probe from the bath containing with $\text{HC}\equiv\text{C}_4\text{H}_7$ showed flat in top. By comparing the bath with $\text{HOH}_2\text{C}_2=\text{C}_2\text{H}_2\text{OH}$ or $\text{H}_3\text{C}_2\equiv\text{C}_2\text{H}_2\text{OH}$ (2-Butyn-1-ol) for investigating the effect of number of OH group, the oval shaped probes with high aspect ratio were formed from the both baths. However, using $\text{HOH}_2\text{C}_2=\text{C}_2\text{H}_2\text{OH}$ bath, many defects in probes were observed, and it was very difficult to form homogenous probes.

From these results, it was found that not only the unsaturated bonding but also the number of OH group in the additive molecule greatly affected on the mass of deposits and shape of probes. The number of carbon in the additive molecule slightly affected to the shape of probes. Oval shaped probes with a high aspect ratio and uniform deposition could be obtained by using the additives triple bond and one OH group.

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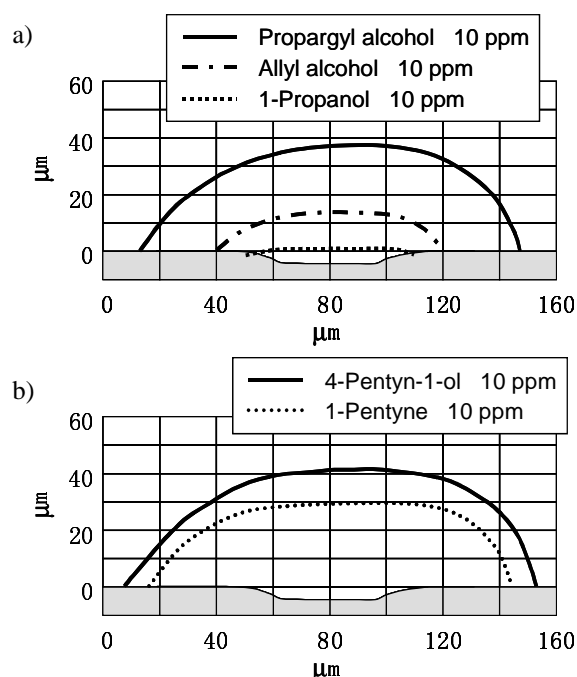


Fig.1 Shape profiles of Ni microprobe electrodeposited with various additives. Unbalanced shape in right and left sides comes from the one-way movement of needle of the profile meter.